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# APPLICATION

OF

RUSSELL E. PRENTICE

FOR

# UNITED STATES PATENT

ON

CAMERA SHUTTER MECHANISM

Case No. 57-14

No. of Drawing Sheets 3

Assignee

**Hycon Mfg. Company**

Attorney of Record

Forrest J. Lilly

## SPECIFICATION

TO ALL WHOM IT MAY CONCERN:

Be it known that I, Russell E. Prentice

a citizen of the United States of America

and resident of Smithtown, Long Island

in the County of Suffolk

and State of New York

have invented a new and useful Camera Shutter Mechanism

of which the following is a specification:



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This invention relates to shutter mechanisms for cameras, and particularly to a new and improved high speed shutter mechanism for aerial cameras and the like.

High speed cameras, such as are employed in aerial survey and military photo-reconnaissance work, require shutter mechanisms which are extremely fast in operation, accurately timed, compact, and capable of prolonged service without adjustment or repair.

Conventional shutter mechanisms embodying shutter blades which are oscillated or reciprocated during each exposure are not capable of satisfying these requirements, primarily because of the excessive wear and strain on the shutter parts resulting from reversal of the shutter blades at high shutter speeds. Further, the time required to arrest and then reverse the direction of movement of the shutter blades severely limits the minimum exposure time which can be achieved.

Various shutter mechanisms have been devised for overcoming the above and other deficiencies of oscillatory type shutter mechanisms. Generally, these shutters employ shutter elements which undergo only unidirectional movement during each exposure so as to avoid the deleterious effects attendant to reversing rapidly moving shutter blades.

At the high speeds involved in the operation of shutter mechanisms of the type under discussion, the moving parts of the mechanisms possess substantial kinetic energy at the ends of their stroke. This energy, of course, must be absorbed or dissipated in some manner when the shutter blades are arrested at the end of each exposure.

In order to achieve maximum mechanical efficiency in shutter operation so as to permit a reduction of the power



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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

input requirements to the shutter and thereby enable a reduction in the overall size and mass of the shutter, it is desirable that the energy of the moving shutter parts be converted to some useful function in the mechanism. In existing shutter mechanisms, however, this energy is dissipated in some manner, with the result that the shutters possess low efficiency and require relatively high power inputs.

Even the most precise and durable shutter mechanisms, of course, require periodic adjustment and repair. Servicing of the shutters in aerial cameras, especially those employed for aerial survey work, has posed a problem in the past. That is, it was generally necessary to at least partially disassemble the lens elements of the cameras in order to remove the shutter mechanism for servicing.

Such disassembly of the lens elements disturbed the precise calibration required in aerial survey cameras. It was necessary, therefore, to recalibrate the cameras following each servicing of their shutter mechanisms. This recalibration was performed in the laboratories of the Bureau of Standards and was a costly and time-consuming operation.

With the foregoing preliminary discussion in mind, a broad object of this invention may be stated as being the provision of a new and improved high speed shutter mechanism for aerial cameras and the like.

A more specific object is the provision of a high speed shutter mechanism embodying shutter blades which undergo only unidirectional movement during each exposure.

Another object is the provision of a high speed



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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

shutter mechanism wherein the forces and stresses, arising during operation of the mechanism, are appreciably reduced so as to render the mechanism capable of accurate and prolonged operation without adjustment or repair.

Yet another object is the provision of a high speed shutter mechanism of the character described which possesses high mechanical efficiency and lower power input requirements than existing shutter mechanisms.

A further object is the provision of a high speed shutter mechanism of the character described which is relatively simple in construction, compact in size, and light in weight, so as to be ideally suited to use in aerial cameras and the like.

Yet a further object is the provision of a high speed shutter mechanism of the character described which is designed to be removed from a camera for servicing, without disturbing the optical calibration of the camera.

Other objects, advantages and features of the invention will become readily apparent as the description proceeds.

Briefly, the foregoing and other objects are achieved in the illustrative embodiment of the invention by the provision of an integral shutter assembly, including a supporting frame mounting movable shutter blades, blade operating means, and electrical control circuitry for the blade operating means. This shutter assembly is designed for removable insertion between lens elements of a camera in such manner as to permit removal of the shutter mechanism for servicing without disturbing the optical calibration of the camera.

The shutter mechanism itself comprises a set of double



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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

ended, rotary shutter blades which are normally positioned with one end of the blades in the aperture opening. Each exposure is accomplished by turning the blades in alternately opposite directions, to retract one end of the blades from the aperture, and position the other ends of the blades in the aperture. Thus, the blades are turned in one direction to effect a given exposure and, in the opposite, to effect the next exposure.

The shutter blades are driven from a pair of compression drive springs through a rack, pinion, and ring gear drive. These drive springs are alternately compressed and released to rotate the shutter blades in alternately opposite directions to effect successive exposures.

Thus, during each exposure, the shutter blades are rotated under the action of one of the drive springs, the remaining spring acting as a brake to arrest the moving parts of the shutter at the termination of the exposure.

These springs are accurately matched to give balanced operation, so that the spring, which is currently acting as the braking spring, absorbs most of the energy released by the driving spring. The braking spring is, therefore, partially compressed at the end of the exposure. In order to condition the mechanism for the next exposure, it is only necessary to complete the compression of the braking spring by replacement of the energy lost by friction and absorbed by blade movement during the previous exposure.

The power input requirements and hence the overall size and mass of the shutter mechanism is, therefore, appreciably reduced. Also, owing to the fact that the shutter blades undergo only unidirectional motion during each exposure, the



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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

parts of the mechanism are subject to appreciably reduced shock and strain. The shutter mechanism is, accordingly, capable of prolonged service without adjustment or repair.

The invention may be best understood from the following detailed description taken in connection with the annexed drawings, wherein:

Figure 1 is a top plan view of the present shutter mechanism in one normal closed position, with cover parts removed and frame parts broken away for clarity;

Figure 2 is an enlarged section taken along line 2-2 of Figure 1;

Figure 3 is an enlarged section taken along line 3-3 of Figure 1;

Figure 3a is an enlarged section taken along line 3a-3a of Figure 1;

Figure 4 is a view similar to Figure 1, with parts in section and the shutter blades of the mechanism in wide open position;

Figure 5 is an enlarged section through the shutter blade operating assembly of the mechanism;



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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Figure 6 is an enlarged detail of certain latch means embodied in the mechanism;

Figure 7 illustrates the present shutter, on reduced scale, installed in a camera;

Figure 8 is a side elevation of the present shutter; and

Figure 9 is a schematic diagram of certain electrical control circuitry embodied in the invention.



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Referring now to these drawings, the present shutter mechanism will be seen to comprise a frame 20, including a pair of normally upper and lower frame sections 22 and 24. Lower frame section 24 comprises a generally rectangular base portion 26 and a tapered, terminally rounded portion 28.

Tapered portion 28 of the lower frame section comprises a wall 30, formed with a flat upper surface 32. Opening through the wall 30 is a circular aperture opening 34.

Formed along the inclined and circular edges of the lower frame wall 30 are a pair of upstanding flanges 38 and a series of spaced, upstanding abutments 40. In the assembled condition of the frame sections, the upper frame section 22 rests on the upper edges of the flanges 38 and abutments 40, so as to be spaced from the lower frame wall 30. Screws 42 secure the frame sections together.

The flanges 38 and abutments 40 are spaced to define in the assembled frame a series of elongate, radial openings 44 through which the shutter blades 46 of the mechanism are adapted to extend, as will be presently described. Formed in the upper frame section, concentric with the opening 34 in the lower frame section, is an aperture opening 48.

Shutter blades 46 are identical and each comprises an elongate blade element which is generally symmetrical about a transverse center line and formed with sector-shaped ends 46a and 46b. Rigid on each blade element intermediate the ends of the latter is a transverse shaft 50.

As shown, the several shutter blades are located in the space between the frame sections 22 and 24. Opposite ends of the shutter blade shafts 50 are journalled in the



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

frame sections for rotation of the shutter blades about axes extending normal to the lower frame wall 30 and equiangularly spaced about the axis of the aperture openings 34, 48. These axes of blade rotation are radially spaced from the axes of the aperture openings a distance somewhat greater than the radius of the openings, as shown.

Rigid on each of the shutter blade shafts 50 at the normally upper sides of the shutter blades is a sector gear 52. The several sector gears 52 are disposed in a common plane paralleling the frame wall 30, while the several shutter blades 46 are disposed in overlapping fashion, as shown.

Normally, that is between exposures, the shutter blades are positioned with one or the other of their ends 46a or 46b in line with the aperture openings 34, 48, so as to close the latter. Figure 1, for example, shows the shutter blades in one normal position with their ends 46a in line with the aperture openings. When in normal position, the outer ends of the shutter blades extend through the radial slots 44 in the frame, as shown.

During operation of the shutter mechanism, to be hereinafter more fully described, an exposure is effected by simultaneously turning the blades in a given direction from one normal position, wherein one end of the blades cover the aperture openings, through the intermediate position of Figure 4 wherein the aperture is fully open, to the other normal blade position wherein the aperture is closed by the other ends of the blades. During the next exposure, the blades are turned in the opposite direction from the latter normal position to their original normal position.



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

It will be observed that in the intermediate shutter blade position of Figure 4, the inner concave edges 46c of the shutter blades define a generally circular aperture opening substantially equal in size to the aperture openings 36, 48 in the frame sections.

The shutter blades are oscillated in the manner described above, by shutter drive means comprising a ring gear 54 formed with circumferentially spaced, toothed sectors 56, each meshing with one of the shutter blade pinions 52. Ring gear 54 is located in a circular slot 58 opening through a wall 60 of the upper frame section 22, and extending across the undersides of a series of radial reinforcing ribs 62 of the latter frame section. These ribs have recesses in their underside, as shown, in which the shutter blade pinions are located coplanar with the ring gear.

The ring gear is journalled on the upper frame section by a series of bearing rollers 64 which are rotatably supported on the frame sections 22 and 24 in the manner shown in Figure 3. These rollers are located opposite the several shutter blade pinions 52 and engage in peripheral grooves 66 formed in the outer cylindrical surface of the ring gear.

During operation of the mechanism, the ring gear 54 is oscillated through a given angle to oscillate the shutter blades 46 between their aforesaid normal positions. Oscillation of the ring gear is limited to this given angle by means of a pin 67 fixed to one of the reinforcing ribs 62 of the upper frame section, and extending through an arcuate slot 68 in the ring gear.

Ring gear 54 is driven in opposite directions by a drive spring assembly, generally indicated at 70. This drive



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

assembly comprises a reciprocable rack 72 which is moved in one longitudinal direction during a given exposure, and in the opposite longitudinal direction during the next exposure. A pinion 74, journalled on the upper frame section 22 and meshing with the ring gear 54 and the rack 72, serves to convert this opposite longitudinal movement of the rack to angular movement of the ring gear through its aforesaid given angle.

Rack 72 is fixed to a slug 76 which is slideably and non-rotatably received in a sleeve 78. The rack projects exteriorly of the sleeve, for engagement with the pinion 74, through an elongate slot in the wall of the sleeve. Sleeve 78 forms part of a movable carriage, which is generally designated by the numeral 80.

Carriage 80 further includes a generally rectangular base plate 82 to which the sleeve 78 is rigidly secured. Carriage 80 is movably supported on the rectangular base portion 26 of the lower frame section 24 by means of four bearing rollers 84.

Bearing rollers 84, which are similar to the ring gear supporting bearing rollers 64, are journalled on the lower frame section and peripherally engage in grooves 86 in the opposite side edges of the carriage base plate 82. The sleeve 78 is thereby supported on the lower frame section for right and left hand axial movement, as the mechanism is viewed in the drawings.

Positioned within opposite ends of the sleeve 78 are a pair of compression drive springs 88 and 90. These springs abut at opposite ends the adjacent end of the slug 76 and closure plugs 92, which are threaded in the ends of



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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

the sleeve 78, as shown.

During operation of the mechanism, the slug 76 is moved in opposite directions, to oscillate the shutter blades 46, by the action of the drive springs 88 and 90. The plugs 92 are adjustable, by threading thereof into and out of the sleeve 78, for the purpose of equalizing the tension of the drive springs to achieve balanced operation, as will be presently more fully discussed.

Generally indicated at 94 is a motor drive assembly for moving the carriage 80, and the sleeve 78 thereon, in opposite axial directions. This motor drive assembly comprises a reversible d.c. motor 96 which rotates a final driven gear 98 through suitable reduction gearing 100. Driven gear 98, in turn, meshes with a rack gear 102, fixed to the carriage plate 82.

Operation of the motor 96, therefore, drives the carriage 80 in one direction or the other, depending on the direction of rotation of the motor. A manual knob 104 is provided for manually turning the driven gear 98 to move the carriage.

Generally indicated at 106 is a latch assembly for releaseably retaining the slug 76 against movement with the carriage 80. This latch assembly comprises an upstanding latch support 108 fixed to the base portion of the lower frame section 24 directly below and centrally of the carriage 80, as the mechanism is viewed in Figure 1.

Pivotally connected at one end to opposite ends of the latch support 108 are a pair of arresting latch fingers 110 and 112. The tip of the left hand latch finger 110 overlies the tip of the right hand latch finger, as shown. The



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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

tips of these latch fingers are biased toward the carriage 80 and against a projecting latch block 116 on the movable slug 76 by a spring wire 117. Latch block 116 projects exteriorly of sleeve 78, for contact with the latch fingers, through an elongate slot in the wall of the sleeve, as shown.

The edges of the latch fingers 110, 112, engageable with the latch block, are notched adjacent the tips of the fingers to form shoulders 118 and 120. These finger shoulders 118 and 120 are engageable with shoulders 122 and 124, formed on the latch block 116, to retain the slug 76 against movement in one direction or the other.

Thus, when the slug is moved to its right hand limiting position, as the mechanism is viewed in Figure 4, wherein the ring gear 54 is rotated in a clockwise direction to one limit of its angular movement to turn the shutter blades 46 to one of their aforesaid normal positions, shoulder 118 on latch finger 110 engages the left hand latch block shoulder 122 to latch the slug against left hand movement.

Similarly, when the slug 76 is moved to its left hand limiting position, wherein the ring gear 54 is rotated in a counterclockwise direction to the other limit of its angular movement to turn the shutter plates to their other normal position, the shoulder 120 on the latch finger 112 engages the right hand latch block shoulder 124 to latch the slug 76 against right hand movement.

The latch block shoulders 122 and 124 are inclined at a $5^{\circ}$ angle relative to the shoulders 118 and 120 of the latch fingers, as shown in the detail of Figure 6, to promote proper engagement and disengagement of these shoulders during operation of the mechanism, as will be described.



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Also embodied on the latch assembly 106 is a trip latch comprising a latch plate 126 located between the shoulders 118 and 120 of the latch fingers. This latch plate is pivotally connected along one edge to the base of the latch support 108 on that side of the latter proximate to the carriage 80.

As shown most clearly in Figure 2 , the free end of the latch plate 126 is located below the plane of the under latch finger 112 and just above the plane of the underside of the latch block 116. The latch plate 126 is swingable between its solid line latching position of Figure 2 , wherein the free end of the latch plate is located in the path of the latch block shoulders 122, 124, and its phantom line released position of the latter Figure. In this released position, the free end of the latch plate clears the latch block.

Normally, the latch plate is retained in its solid line latching position by a coil compression spring 128, shown in Figure 2 . Retraction of the latch plate to its released position is effected by energizing of a solenoid 130 including a headed plunger 132 which extends loosely through an enlarged opening in the plate. When the solenoid is energized, the plunger 132 is drawn downwardly, as viewed in Figure 2 . The head on the plunger is thereby engaged with the latch plate to rock the latter to its phantom line, released position.

The opposite side edges 134 and 136 of the latch plate, which edges are engageable with the latch block shoulders 122, 124 as described below, are disposed just slightly behind the adjacent shoulders 118, 120 on the latch



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

fingers 110 and 112, as may be most readily observed in Figure 6. It will be clear, therefore, that when either of the shoulders on the latch fingers is engaged with its respective latch block shoulder 122 or 124 to latch the slug 76 against movement in one direction or the other, the latch plate 126 may freely rock to its latching position in the path of the engaged latch block shoulder. The latch block engaging edges 134, 136 of the latch plate parallel the latch block shoulders 122, 124, as shown.

Fixed to the carriage sleeve 78, centrally thereof, is a cam plate 138. Cam plate 138 is of generally rectangular configuration and has two of its corners bevelled to form cam faces 140 and 142. These cam faces are engageable with upstanding pins 144 on the latch fingers 110 and 112 during movement of the carriage 80 in opposite directions for camming the latch fingers out of latching engagement with the latch block 116, as will be presently described.

Figure 9 schematically illustrates an electrical control circuit embodied in the present shutter mechanism. This control circuit comprises a pair of double pole, double throw, left and right hand start switches 146 and 148, respectively. Referring to Figure 1, these switches will be seen to be mounted on the lower frame section 24 at opposite ends of the rack gear 72 fixed to the movable slug 76. The rack gear is formed at its ends with projecting shoulders 150 engageable, at opposite ends of the stroke of the slug, with the plungers 146a and 148a of the start switches 146 and 148.

Surrounding the plungers 146a and 148a are springs 152 for biasing the left hand plunger 146a toward the right



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

to a position wherein the right hand contacts 146b of the left start switch 146 are closed, and biasing the right hand plunger 148a toward the left to a position wherein the left hand contacts 148b of the right hand start switch are closed. The parts are so located that the left hand rack shoulder 150 engages the plunger 146a of the left hand start switch 146, to open the normally closed contacts 146b and close the normally open contacts 146c of the latter switch, upon left hand movement of the slug 116 to a position slightly short of its left hand limiting position wherein the right hand latch finger 112 snaps into place in front of the right hand latch block shoulder 124.

Similarly, the right hand rack shoulder engages the plunger 148a of the right hand start switch 148, to open the normally closed contacts 148b and close the normally open contacts 148c of the latter switch, upon right hand movement of the slug 116 to a position just slightly short of its right hand limiting position wherein the left hand latch finger 110 snaps into place in front of the left hand latch block shoulder 122.

Indicated at 154 and 156 are a pair of right and left limit switches. These switches are mounted one over the other on the lower frame section 24 adjacent the lower right hand corner of the carriage plate 82, as the mechanism is viewed in Figure 1 . The activating elements 154a and 156a of these switches are engageable with elongate cam elements 158 and 160 mounted one over the other on the carriage plate 82, as shown. The right limit switch 154 is normally open while the left limit switch 156 is normally closed.

The cam elements 158 and 160 are formed with re-



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

cesses 162 and intermediate inclined cam faces 164, as shown. The limit switches occupy their above-described normal positions when their respective actuating elements 154a and 156a are engaged in the cam recesses 162 and are operated to their other positions during relative travel of the actuating elements over the inclined cam faces 164 to the raised portions of the cams.

The inclined cam face on the lower cam element 160, associated with the left limit switch 156 is offset slightly to the right, as viewed in Figure 1, relative to the inclined cam face on the upper cam element for reasons to be described. Means 166 are provided for axially adjusting the cam elements to vary this offset of the inclined cam faces 164, as well as to locate the inclined cam faces in predetermined relation to the carriage 80, as will be presently discussed.

The control circuit of the mechanism further embodies a pair of relays 168 and 170 which are supported in side-by-side fashion on the lower frame section, as shown in Figure 1.

Relay 168 comprises a coil 168a and a pair of contact sets 172 and 174 including, respectively, normally closed contacts 172a, 174a, and normally open contacts 172b, 174b. Relay 170 comprises a coil 170a in shunt with the motor 96 and normally closed contacts 176 in series with the latch plate solenoid 130. These various circuit elements are connected as shown in Figure 9.



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

## OPERATION

The parts of the mechanism will be assumed to be initially in their intermediate position of Figure 4 In this condition of the mechanism, the carriage 80 is located in a centered position intermediate the limits of its travel.

The slug 76, which is now unlatched so as to be freely movable in the carriage sleeve 78, is retained in a center position in the sleeve by the drive springs 88 and 90. The tension in these springs, of course, is now equalized. The threaded plugs 92 in the ends of the carriage sleeve permit adjustment of the initial tension in the drive springs, as well as centering of the slug 76 in the carriage sleeve.

The latch block 116 is now centered with respect to the latch shoulders 118 and 120 of the latch fingers 110 and 112 and the latch plate 126. Since the slug 76 is in its center position, the shutter blades 46 occupy their intermediate, wide open position of Figure 4 , and the right and left hand start switches are in their normal, solid line positions of Figure 9.

When a d.c. voltage is impressed on the input terminals 178, 180 (Figure 9 ) of the shutter mechanism, coil 168a of relay 168 is energized through a circuit extending from the positive input terminal 178, lead 182, now closed left hand start switch contacts 146b, lead 184, now closed right hand start switch contacts 148b, and lead 186 to one end of relay coil 168a, and from the other end of the latter coil to the negative input terminal 180. This energizing of coil 168a results in opening of its normally closed contacts



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

172a and 174a and closure of its normally open contacts 172b and 174b.

An energizing circuit through the shutter drive motor is now completed from the input terminal 178, through lead 182, start switch contacts 146b, lead 184, start switch contacts 148b, lead 186, lead 188, relay contacts 172b, motor 96, relay contacts 174b, and lead 190 to the negative d.c. terminal 180. The motor is polarized to now drive the carriage toward the left, as viewed in Figure 1 . The slug 72, of course, moves to left with the carriage. The shutter blades 46 are thereby turned to one of their normal closed positions.

During travel of the carriage to the left, the right limit switch 154 is closed by relative movement of its actuating element 154a out of the recess 162 and onto the raised cam surface portion of its cam element 158. Upon movement of the carriage 80 to the left to a position (Figure 1 ) wherein the right hand latch block shoulder 124 just clears the shoulder 120 on the right hand latch finger 112, the latter and the trip latch plate 126 snap in behind the latch block to latch the latter against right hand movement. The left start switch 146 is now operated to its phantom line position by engagement of its plunger 146a with the slug rack gear 72.

This action cuts the power to the motor 96 and the relay 168. Since the slug 76 is now latched against right hand movement, left start switch remains in its phantom line position and relay 168 remains deenergized. Since the contacts 146c of the left start switch 146 and the right limit switch 154 are now closed and the contacts of



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

relay 168 occupy their normal position, motor 96 is immediately reenergized for reverse rotation to drive the carriage 80 to the right. The energizing circuit for the motor is now from the d.c. terminal 178, through lead 182, left start switch contacts 146c, lead 192, right limit switch 154, lead 194, relay contacts 174a, motor 96, relay contacts 172a, and lead 196 to the negative d.c. terminal 180.

During this movement of the carriage to the right, the left hand drive spring 88 is compressed against the slug 76 which, as just mentioned, is latched in its left hand limiting position wherein the shutter blades 46 are in one normal position closing the shutter aperture. Engagement of the cam plate 138 on the carriage with the right hand latch finger pin 144 during this right hand travel of the carriage retracts the latch finger 112 to its released position. The trip latch plate 126, however, retains the slug 76 in its left hand latching position.

Right hand movement of the carriage is terminated by return of the right limit switch 154 to its manual open condition which cuts the power to the motor 96. This return of the limit switch 154 to its normal condition, of course, occurs when the actuating element 154a of the switch rides into the recess 162 of the upper cam element 158. The upper cam element is so axially adjusted that the right limit switch is thus opened when the carriage 80 has been driven to a position (Figure 5 ) slightly past its center position, as discussed more fully below. The shutter mechanism is now conditioned for an exposure.

An exposure is initiated by energizing the trip



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

latch solenoid 130 to retract the latch plate 126 and thereby release the slug 76 for right hand movement in the carriage sleeve 78 under the action of the now compressed, left hand drive spring 88. The solenoid 130 is energized by applying a pulse to its input terminals 198. Since motor 96 is now deenergized, relay coil 170a in shunt with the motor is also deenergized and its contacts 176 are in their normally closed position. The solenoid is, therefore, energized by the pulse and the slug 76 is released, as just mentioned.

Upon release, slug 76 is propelled to a right hand limiting position wherein the left hand latch finger 110, which clears the cam plate 138 in the present right hand position of the carriage 80, snaps in behind the left hand latch block shoulder 122. The slug 76 is then latched against left hand movement.

During this right hand travel of the slug 76, the shutter blades 46 are turned in one direction from their normal closed position of Figure 1 , through their intermediate position of Figure 4 , to their other normal closed position to effect an exposure. Upon latching of the slug in its right hand limiting position, therefore, the shutter aperture is reclosed.

As preliminarily mentioned, during each exposure, one drive spring operates the shutter blades, and the other drive spring acts as a brake to arrest the moving parts of the mechanism. Thus, during the above right hand travel of the slug 76, the right hand drive spring 90 acts as a brake. As earlier noted, the drive springs comprise a matched set. The right hand spring, therefore, absorbs a substantial por-



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

tion of the energy released by the compressed, left hand driving spring during the first exposure and is thus partially compressed when right hand movement of the slug is finally arrested.

When the mechanism is properly adjusted, the slug is arrested in its right hand travel slightly beyond its right hand latching position wherein the left hand latch block shoulder 122 just clears the shoulder 118 on the left hand latch finger 110. This permits the latter finger to snap in behind the latch block and latch the slug against left hand movement.

To this end, the cam element 150, associated with the right limit switch 154, is so initially axially adjusted by the means 166 as to effect initial driving of the carriage 80 to the right to a position whereat the left hand drive spring 88 is sufficiently compressed to accomplish propelling of the slug slightly beyond its right hand latching position, in the manner just mentioned.

During the second exposure, the slug 76 is propelled to the left by the right hand drive spring 90, the left hand spring 88, in this instance, acting as a brake to arrest the slug slightly beyond its left hand latching position. Owing to friction and inertial losses, of course, the energy absorbed by the right hand drive spring 90 during the first exposure is less than that released by the left drive spring 88. The partial compression of the right drive spring 90 by the slug at the end of the first exposure is, therefore, insufficient to propel the slug 76 to its left hand latching position, and thereby complete the second exposure.

To condition the mechanism for the second exposure,



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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

therefore, additional energy, at least equal to that lost during the first exposure, must be added to the right hand drive spring 90 at the end of the first exposure. This additional energy is supplied by the motor 96 which automatically drives the carriage 80 to the left at the end of the first exposure. The right hand drive spring 90 is thereby additionally compressed against the slug 76, which is then latched in its right hand limiting position.

The right hand drive spring is thus additionally compressed until its compression substantially equals that possessed by the left hand drive spring 88 at the initiation of the first exposure.

This movement of the carriage to the left is accomplished as follows. Upon release of the slug 76 for right hand movement during the first exposure, the left start switch 146 is returned to its normal solid condition with resultant reclosing of its contacts 146b. Immediately thereafter the slug engages the plunger 148a of the right start switch 148 and operates the latter to its phantom line condition. Latching of the slug in its right hand limiting position, in the manner described above, retains the right start switch in this condition. Since the carriage 80 is, at this time, in its right hand limiting position, the left limit switch 156 is in its normally closed position owing to engagement of its actuating element 156a in the recess 162 of its associated cam element 160.

Relay 168 is now energized through a circuit extending from the d.c. terminal 178, lead 182, right start switch contacts 148c, left limit switch 156, lead 188, coil 168a, to the negative d.c. terminal 180. With relay



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

168 thus energized, motor 96 is energized, to drive the carriage 80 to the left, from the d.c. terminal 178, through the left limit switch 156, lead 188, now closed relay contact 172b and 174b, and lead 190 connected to the negative d.c. terminal 180.

Motor 96 is thus energized to drive the carriage 80 to the left. The right hand drive spring 90 is thereby compressed against the slug 76 which is latched in its right hand limiting position, as mentioned above.

This left hand travel of the carriage continues until the left limit switch 156 is opened by engagement of its actuating element 156a with the inclined cam face 164 of its associated cam element 160. The power to the relay 168 and the motor 96 is thereby cut off.

The cam element 160 is initially so axially adjusted, by means 166, that this left hand travel of the carriage is terminated, as previously indicated, when the compression of the right hand drive spring 90 is sufficient to propel the slug 76 to its left hand latching position. The carriage 80 is then located slightly to the left of its center position, and this compression of the right hand drive spring approximately equals the compression of the left hand drive spring 88 at the initiation of the first exposure.

During this left hand travel of the carriage, the cam plate 138 on the carriage engages the pin 144 on the left hand latch finger 110 and cams the latter to its released position. Since the motor 96 is energized, however, the relay coil 170a in shunt with the motor is also energized. Its relay contacts 176, in series with the trip latch sole -



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

noid 130, are, therefore, open, and the solenoid 130 will be deenergized even though the pulse which initiated the first exposure is still applied to the solenoid terminals. The latch plate 126 will thus have been returned to its latching position, in the path of the slug latch block 116, prior to release of the left hand latch finger 110. The slug 76, therefore, remains latched in its right hand limiting position.

The shutter mechanism is now conditioned for the second exposure which is again initiated by energizing the trip latch solenoid 130. When the solenoid is again energized to retract the trip latch plate 126, the slug 76 is released and propelled to the left by the now compressed right hand drive spring 90. During this left hand travel of the slug, the shutter blades 46 are rotated, in a direction opposite to their rotation during the first exposure, to effect the second exposure.

Movement of the slug 76 to the left is arrested by the left hand drive spring 88 when the slug is just slightly beyond its left hand latching position. The right hand latch finger 112 now snaps in behind the latch block 116 to latch the slug in this latter position.

During arresting of the slug 76, the left hand drive spring absorbs a portion of the energy released by the right hand spring and is thereby partially compressed in the same manner as the right hand drive spring during the first exposure. As before, however, the energy losses occurring during the second exposure must be supplied to the left hand drive spring 88 to condition the mechanism for the third exposure. This is accomplished by driving of the carriage



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

80 to the right to the position it occupied at the initiation of the first exposure.

Thus, when the slug 76 is released to effect the second exposure, the right start switch 148 is returned to its normal condition and immediately thereafter the left start switch 146 is operated to its phantom line position by the slug. Also, since the carriage 80 is, at this time, at the left hand limit of its travel, left limit switch 156 is open, as mentioned above, and the right limit switch 154 is closed. Relay 168 is now deenergized.

The motor 96 is now energized, in the manner described with reference to operation of the mechanism, prior to the first exposure, i.e., through contacts 146c of the left start switch 146 and right limit switch 154.

Motor 96, therefore, drives the carriage 80 to the right and the left hand drive spring 88 is again compressed against the slug 76 which is now latched in its left hand position.

During this right hand movement of the carriage, the currently engaged latch finger 112 is cammed to its released position. The trip latch relay 170a is now energized, however, so that the trip latch plate 126 is in its latching position in front of the latch block 116. The slug is thereby retained in its left hand latching position, as before.

Upon opening of the right limit switch 154 to terminate right hand movement of the carriage, in the manner described with reference to conditioning of the mechanism for the first exposure, the mechanism is conditioned for initiation of the third exposure. Operation of the mechanism during this third, as well as every odd numbered expos-



Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

ure thereafter, is identical to its operation during the first exposure. Similarly, operation of the mechanism during the fourth and every even numbered exposure thereafter is identical to its operation during the second exposure.

From the above description, it will be clear that the shutter bladen 46 are turned in only one direction during each exposure. Shock and strain on the mechanism is thereby substantially reduced. The mechanism is, therefore, subject to reduced wear so as to be capable of prolonged operation without adjustment or repair.

Further, owing to the alternate use of the drive springs as brakes, so as to absorb a portion of the energy released by the driving spring, the mechanical efficiency of the mechanism is greatly enhanced. The power input requirements to the mechanism, as well as its size and mass, are, therefore, substantially reduced.

As shown in Figure 7, the frame 20 of the present shutter mechanism is designed for removable insertion between lens elements L of a camera C. To this end, the camera will be provided with suitable guides (not shown) for slideably receiving the shutter frame, as well as light seals (not shown) to prevent leakage of light into the camera. The shutter mechanism may, therefore, be removed from the camera for servicing without disturbing the optics of the camera.

Numerous modifications in design, arrangement of parts, and instrumentalities of the invention will be apparent within the scope of the following claims.

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Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

I CLAIM:

1. A shutter mechanism comprising: means defining a light aperture, a movable shutter blade having a pair of spaced blade portions and movable in one direction to a first closed position wherein one of said blade portions is located in said aperture and the other blade portion is retracted from the aperture and in the opposite direction to a second closed position wherein the positions of said blade portions are reversed, said blade uncovering said aperture during movement between said positions to effect an exposure, and drive means for moving said blade between said closed positionsto effect successive exposures by movement of the blade in one of said directions during a given exposure and in the opposite direction during the next exposure.

2. The subject matter of claim 1 wherein said blade is movable in rotation between said closed positions about an axis intermediate the ends of the blade, said ends of the blade comprising said spaced blade portions.

3. The subject matter of claim 1 wherein said drive means comprises a movable member operatively connected to said blade to move the latter and movable in opposite directions between given limiting positions to move said blade in opposite directions between said closed positions, means for releaseably latching said member in said limiting positions, and yieldable means for moving said member between said limiting positions when said member is released.

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

4. The subject matter of claim 1 wherein said drive means comprises a movable member operatively connected to said blade to move the latter and movable in opposite directions between given limiting positions to move said blade in opposite directions between said closed positions, means for releaseably latching said member in said limiting positions, a pair of yieldable means for moving said member in opposite directions between said limiting positions when said member is released, and means for alternately rendering said yieldable means effective to move said member.

5. The subject matter of claim 1 wherein said drive means comprises a movable member operatively connected to said blade to move the latter and movable in opposite directions between given limiting positions to move said blade in opposite directions between said closed positions, means for releaseably latching said member in said limiting positions, yieldable means for moving said member in alternately opposite directions when released to effect successive exposures and for braking said member at the end of each exposure, said yieldable means being partially tensed in response to braking of said member at the end of each exposure in a direction to partially condition said mechanism for the next exposure, means for additionally tensing said yieldable means at the end of each exposure to complete the conditioning of said mechanism for the next exposure.

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

6. The subject matter of claim 5 wherein said yieldable means comprises a pair of springs engaging opposite sides of said member for alternately moving said member in said opposite directions to effect successive exposures, one of said springs moving said member and the other spring braking said member during each exposure, said other spring being partially tensed at the end of each exposure in response to braking of the member, and said means for additionally tensing said yieldable means comprising means for additionally tensing said other spring at the end of each exposure.

7. A shutter mechanism comprising: means defining a light aperture, a movable shutter blade having a pair of spaced blade portions and movable in one direction to a first closed position wherein one of said blade portions is located in said aperture and the other blade portion is retracted from the aperture and in the opposite direction to a second closed position wherein the positions of said blade portions are reversed, said blade uncovering said aperture during movement between said positions to effect an exposure, drive means for moving said blade between said closed positions to effect successive exposures by movement of the blade in one of said directions during a given exposure and in the opposite direction during the next exposure, said drive means comprising a member operatively connected to said shutter blade for moving the latter and movable in opposite directions between given limiting positions to move said blade in opposite directions between said closed positions, a carriage supporting said member for movement between said limiting positions and movable in said carriage being movable said opposite directions of movement of said member, a pair of springs at opposite sides of said member and engaging the latter at one end of said carriage and the other end for alternately moving said member between

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

said limiting positions, means for releaseably latching said member in said limiting positions against movement to move said blade while permitting movement of the carriage relative to said member, and means for moving said carriage in opposite directions relative to said member when the latter is latched in said limiting positions whereby to enable alternate tensing of said springs and conditioning of the mechanism for successive exposures.

8. The subject matter of claim 7 during each exposure one of said springs acts to move said member to effect the exposure and the other spring acts to braking said member at the end of the exposure and is thereby partially tensed, and said carriage being movable at the end of each exposure to additionally tense said other spring.

9. The subject matter of claim 7 wherein said carriage is moved in one direction at the end of one exposure and in the opposite direction at the end of the next exposure, said means for moving the carriage comprising electrical drive means and control means for said drive means automatically operative at the end of each exposure to cause movement of the carriage in a direction to condition the mechanism for the next exposure.

10. The subject matter of claim 9 wherein said control means comprises means for adjustably controlling carriage travel at the end of each exposure.

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

11. A shutter mechanism comprising: means defining a light aperture, a movable shutter blade having a pair of spaced blade portions and movable in one direction to a first closed position wherein one of said blade portions is located in said aperture and the other blade portion is retracted from the aperture and in the opposite direction to a second closed position wherein the positions of said blade portions are reversed, said blade uncovering said aperture during movement between said positions to effect an exposure, drive means for moving said blade between said closed positions to effect successive exposures by movement of the blade in one of said directions during a given exposure and in the opposite direction during the next exposure, said drive means comprising a member operatively connected to said shutter blade for moving the latter and movable in opposite directions between given limiting positions to move said blade in opposite directions between said closed positions, yieldable means for moving said member between said limiting positions when released, said yieldable means being adapted to be tensed when said member is latched in each of said limiting positions in a direction to cause movement of the member to the opposite limiting position, and means responsive to latching of said member in each of said limiting positions to tense said yieldable means in a direction to cause subsequent movement of said member when released to the opposite limiting position.

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

12. A shutter blade drive for a shutter mechanism, comprising a shutter drive member movable in opposite directions between given limiting positions, releaseable means responsive to movement of said member to each of said positions for latching the member in said positions, member operatively connected to said blade to move the latter and movable in opposite directions between given limiting positions to move said blade in opposite directions between said closed positions, means for releaseably latching said member in said limiting positions.

13. A shutter blade drive for a shutter mechanism, comprising a support, a carriage movable in opposite directions on the support, a blade operating member on said carriage and movable in said opposite directions relative to the carriage, means for releaseably latching said member to the support in spaced limiting positions, and yieldable means engaging between said carriage and member for exerting an unbalanced yieldable force on the member in response to movement of the latter in either direction from a given normal position relative to the carriage and in the direction of said given position whereby when said member is latched in one of said limiting positions, said member may be resiliently biased toward the other limiting position by movement of the carriage toward the latter position.

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6

14. The subject matter of claim 13 including means responsive to latching of said member in either of said limiting positions for driving the carriage to a given position toward the opposite limiting position.

Declassified and Approved For Release 2012/06/14 : CIA-RDP89B00487R000400690001-6